ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA

2019

SCIENCE GAMES

SATURDAY, MARCH 2, 2019

DIVISION 1 TAKE HOME ACTIVITY
HOME SAFE HOME

Engineers work hard to design and create things all around you. Civil engineers are a special type of engineer that makes sure buildings are safe for people to use and live in. They have to think about how the environment around a home or office can impact the building. How will a house keep people safe during a wind storm? How will a house keep people safe during a rainstorm? These are questions that civil engineers need to think about.

The materials used to create these buildings can also impact their environment. Over the past several years, more and more engineers have been looking at ways to build things that are sustainable. This means that they use materials and build these structures in an environmentally friendly way. This could mean designing a house that uses solar energy or has a green roof. Your team's sustainable home should collect rainwater.

In this activity Division 1 teams will need to design and build a sustainable house. Your house should be strong enough to withstand wind and built so no water gets inside the house. Your house's roof should be designed so that rain water can be collected from your home.

Teams will be awarded points based on your house design, how it withstands rain and wind tests, how you answer questions about sustainability, and teamwork.

INSTRUCTIONS

1. **Research:** Before you begin building your house, teams will need to learn about how to build a home. What do you need to consider? What materials will you use? How can you make your home more sustainable? What sustainability?

2. **Design and Build a Test Home:** Work together to design and build your test home. Make sure to review the rules to see what items need to be included. Test this home to see how resistant it is to rain and wind. What sustainable components are you building into your model? Don't forget about making your home look nice. After all, you want someone to buy the home once it's finished! If teams have time you can do more than one test homes.

Remember: Your home needs to keep people dry when it rains and protect them from other elements like wind. It should also include some sort of design to manage water flow from the roof. Design your roof so that water will be collected in one area.

3. **Build Your Home:** Use what you learned from your test home to build your final model home. Make sure to double check the Rules section before building your final model.

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4. **Prepare for Your Home Showcase:** At the Science Games, our judges will ask your team about your home's design. Make sure all your team members can answer these questions:

   a. What does sustainability mean?
   b. What are some ways homes can be sustainable or energy efficient?
   c. What do engineers need to think about to make sure what they are designing is sustainable?
   d. What features does your house have to keep the people inside safe?

5. **Bring Your Home to the Science Games:** Prepare your home for transportation to the Science Games. Make sure to bring your completed home to the Science Games for judging.

RULES:

- Your team's house cannot be larger than 20 cm x 20 cm and shouldn't be taller than 20 cm.
- The walls of your house should not be thicker than 1 cm.
- Your team's house must have:
  a. A door that can open and close.
  b. The door needs to be the size of a playing card (approx. 6.3 cm x 8.8 cm).
  c. Windows on opposite sides of the house.
  d. Windows should be 3.5 cm x 3.5 cm.
  e. Windows should be able to open and close.
- Tape should **NOT** be used to secure your windows when closed.
- Houses must **NOT** weigh more than 5 pounds.
- Your water collecting system must leave room for a cup to go beneath it. At the Science Games we will use a standard size plastic cup to collect the water through your system and judge its effectiveness.
- All structural elements needs to be recyclable materials.
- The material used to create your house's roof does not need to be recycled, but it is encouraged.
- Decorative materials must be available for purchase at a dollarstore, or common household items. Decorative materials do not need to be recycled, but it is encouraged.

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DIVISION 1 MYSTERY ACTIVITY

RAINBOW MINE

Earth scientists, also called geoscientists, know a lot about the Earth and what can be found in the ground underneath our feet. They use their knowledge of the Earth to find where useful materials, like minerals may be found. Minerals are the building blocks of many objects that we use in our everyday lives.

Mining engineers are problem solvers. They use their knowledge of science, math, and physics to develop ways to remove these minerals from the ground. When minerals are removed, or mined, the ground around them can be affected. This depends on how the minerals are removed from the ground.

In this activity, Division 1 teams will learn about different mining styles used by engineers and how they impact the surrounding area.

INSTRUCTIONS

1. **Review Your Samples:** Each team member will get their own cookie to review. Write down how many rainbow chips are on your cookie.

2. **Mine Your First Cookie Sample as a Group:** Teams will use chopsticks to mine a cookie provided by a Science Games Judge. The goal is to get the most rainbow chips out of the cookie. Team members will need to work together to mine their first cookie as a group.

Before you start mining, make sure to note how many rainbow chips are visible from the outside of the cookie.

3. **Discussion:** Now that you have mined one cookie talk as a team about what you learned. Was a chopstick a good tool to use? How did it effect the cookie surrounding the rainbow chips? How many rainbow chips could you see before you mined the cookie? How many rainbow chips were you able to successfully remove from the cookie?

4. **Mine Your Own Cookie Sample:** Each team member will be given a new tool to mine their own cookie sample. Team members will use a paper clip to remove the most rainbow chips of the same colour from their cookie sample. But be careful, when mining this sample you must not break the cookie! Each team member can pick any colour of rainbow chip they want to remove. Make sure to think about the placement of the rainbow chips and how many are on your cookie before deciding what rainbow chip colour you will remove.

5. **Discussion:** Now that you have mined a cookie on your own, talk with your team and Science Games judge about what you learned. How was a paper clip as a tool? How many rainbow chips were you able to remove of the same colour? How does this mining style compare to the chopstick method? Why would you pick one tool over the other?

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DIVISION 1 MYSTERY ACTIVITY

RAINBOW MINE

RULES

- Teams can only mine with the tools provided (e.g., chopstick, paper clip).
- Teams cannot use their hands to mine the cookie samples. The only thing that can touch the cookie samples are the tools.
- All team members must participate together in the Group Mining portion of this activity.
- Team members are not allowed to eat the cookie samples.
- Team members should not touch the cookie samples unless a Science Games Judge says it's ok.
- Cookie samples must remain on their plate.
- Teams should leave their activity area tidy.

ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA

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SCIENCE GAMES

SATURDAY, MARCH 2, 2019

DIVISION 1 MYSTERY ACTIVITY

DRIP, DROP, FLOW!

Sand, gravel, clay, oh my! These soil types can be found all over BC. We don't think about it very much, but they play a big role in the world around us. Earth scientists, also called geoscientists, know a lot about the ground underneath our feet. They know how each soil type acts when it rains. Does the water flow through or does it get stopped?

In this activity Division 1 teams will find out as they run through several soil experiments. Teams will also build their own soil sample experiment.

INSTRUCTIONS

1. **Review Your Activity Materials:** Each team will have a set of three jars, a funnel, and some soil samples. Each jar is for its own soil sample experiment. As a team you will review all of these materials. Teams will also receive several guess sheets or Hypothesis Sheets. Teams will need to work together to test how these ground samples respond to water flow.

2. **Pick Your First Jar:** After reviewing the soil sample options, as a team choose the one that you think will allow the most water to flow through the fastest and be the most efficient. This will be the first soil sample that you test.

3. **Record Your Guess:** How long do you think it will take for the water to flow through the soil sample? Write down on the Hypothesis Sheet how long you think it will take.

4. **Do your First Permeability Experiment:** Work as a team to conduct your experiment. As a team you'll need to:
    i. Place a funnel in the glass container.
    ii. Put a paper filter into the funnel.
    iii. Then place your team's first ground sample, sand, gravel, or clay, into the paper filter.
    iv. Pour 200mL of water into the funnel. Make sure to start the timer as you pour.

5. **Record Your Results:** How much water made it through? After you've run your experiment, pour the water that made it through the mason jar, back into the measuring cup. Make sure to record this along with the time.

6. **Experiment with the Other Soil Types:** Repeat these steps for the other two ground materials. Make sure to record a hypothesis for these as well as your results.

7. **Contamination Experiments:** Now as a team you'll repeat these experiments but instead of using water, you will use contaminated material. Contaminants contain a polluting substance that can be harmful to the environment. The contamination experiments will mimic how a harmful substance would react to the environment, like an oil spill or leak from a factory. Repeat each soil experiment with the new contaminant material. Make sure to complete a hypothesis sheet for each one.
    a. Contaminated materials should be 150 mL water and 50 mL of oil.

DIVISION 1 MYSTERY ACTIVITY
DRIP, DROP, FLOW!

8. **Record Your Results:** How much contaminant material made it through? After you've run your experiment make sure to record this along with the time.

9. **Mix it Up:** Now that you've completed these experiments you get to create your own! As a team choose what soil types you want to use in your experiment. You can use different types of soil samples. Teams will need to:

   Record Your Guess: How long do you think it will take for the water to flow through your soil sample? Write down on the Hypothesis Sheet how long you think it will take.

   Set a Goal for the Experiment: Do you want the most water to go through? Do you want the least water to go through? Do you want it to take a long time to filter through? Or do you want it to go through as fast as possible?

   Select Your Ground Materials: How much of each soil sample do you want to put in? Teams must use some of each soil sample in the Mix It Up Experiment.

10. **Run your Mix It Up Experiment:** Now that you've decided what to do for your Mix it Up Experiment, prepare your materials.

11. **Record your Results:** How much water made it through? After you've run your experiment make sure to record this along with the time. How close were you to your experiment goal?

12. **Review What You Learned:** Based on your team's experience, what did you learn from the results of your seven experiments? Teams will need to write down their findings and what they learned for our judges.

RULES

- Teams must start with the three water experiments before moving on to the contamination experiments.
- Teams must record their hypothesis before starting each experiment.
- Teams should not make a mess with the materials.
- Do not mix soil samples (e.g., sand, gravel, clay) in your experiments, except in the Mix It Up Experiment.
- Teams must use some of each soil sample in the Mix It Up Experiment.
- Teams must record what they learned for the judges.

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DIVISION 2 TAKE HOME ACTIVITY
GROUND SHAKES!

The year is 2025 and the new alternative to plane travel is here! It is called “Swift Loop” and it uses vibration energy to propel the cars through an elevated tunnel. While a Swift Loop car starts up from a station, it shakes the land around it...a lot. This event even has its own name, the “Shake”!

The “Shake” is so serious that buildings beside stations need to be rated for a Level 9 earthquake to ensure they are safe and don’t shift. Swift Loop Inc. has hired your engineering firm to solve this shaking problem by looking at the ground underneath the nearby buildings to create a solid foundation. They need geotechnical engineers like you to make the foundation, also called the subsurface or the ground underneath and surrounding these buildings, resistant to shaking.

In this activity, Division 2 teams will have to design and build a subsurface that can support a building when exposed to shaking and other elements, like water.

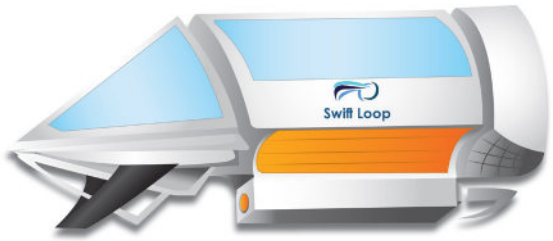

Figure 1: Swift Loop Car

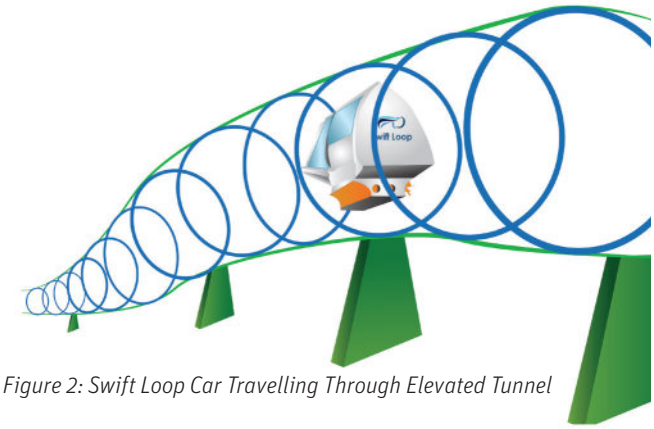

Figure 2: Swift Loop Car Travelling Through Elevated Tunnel

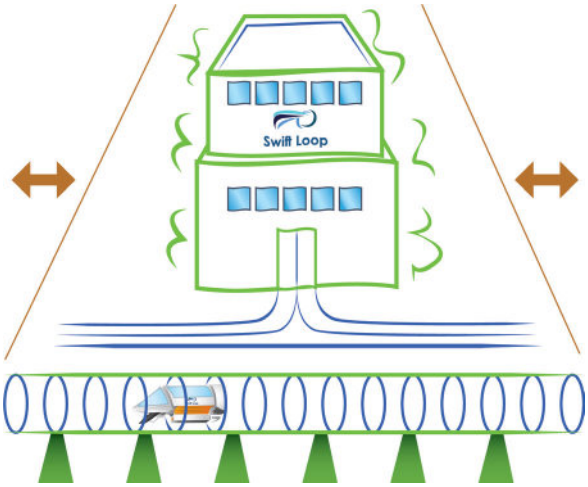

Figure 3: 2-Storey Swift Loop Station with the “Shake”

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GROUND SHAKES!

INSTRUCTIONS

1. **Read the Things to Think About Section:** Review this section (pg. 5 and 6) carefully to learn about how engineers review an area to decide whether or not it's appropriate to build or what they could do to make it a better location to build on. This will help you set up your subsurface—a stable surface that a building can stand on.

2. **Source Your Materials:** Check out our Material Info Sheet (pg. 4) for ideas on what could be used in your team's subsurface. You must use a minimum of 3 different types of materials to make up your subsurface.

3. **Design Your Subsurface Model:** Use the Engineering Drafting Paper templates provided to design your test model. Make sure to bring this to the Science Games, along with your subsurface, to show our judges your process.

Team members should consider: Which layer should be placed at the bottom to make it stable? Which layer should be placed on top so the building won't move? How can you use compaction to create a more stable layer? How does adding or removing water to each layer impact its stability?

4. **Build a Test:** We've provided each team with a springform pan. Use this as the container to create your subsurface. Wax paper has also been provided to line your pan.

5. **Test Your Model:** Remove the sides of the springform pan to see how stable your subsurface is. Once the sides of the pan are removed does your subsurface remain intact? Has the slope of your surface layer stayed the same? At the Science Games, your subsurface will be shaken and exposed to water to test its stability. Make sure to run similar tests on your subsurface model at home.

6. **Review Your Design:** Add comments into your design sheet. How can you modify your design to make it more stable? Make sure to review the Things to Think About section for clues on how to make your subsurface more stable.

7. **Build Your Final Model and Prepare it for Transportation:** Use the shower cap provided as a lid when transporting your subsurface. Be prepared to answer our judges' questions about your subsurface and design at the Science Games.

RULES:

- Materials used to create your subsurface must be available for purchase at a dollarstore, or common household items. Natural materials, such as sand, can also be used.
- Teams **CANNOT USE** glue at all.
- Teams **CANNOT USE** tape at all.

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GROUND SHAKES!

- Teams **MUST** have a peat layer in their subsurface design. Water must be added to mimic the soft peat layer.
- Your team's subsurface should be made up of a minimum of 3 different material types.
- Each material type should have its own distinct layers. Material types cannot be mixed.
- Each layer of your subsurface should be the same thickness.
- Individual material pieces cannot be larger than 1 cm in diameter (e.g., If you used marbles for one of your subsurface layers, they would need to be smaller than 1 cm in diameter).
- No concrete or metal layers can be used in your team's subsurface.
- The building will be positioned in the centre of your team's substructure when you test stability. The building is approximately 60 mm x 60 mm x 60 mm and weights approximately 100 grams.
- Your team must have a design and reasoning before building your substructure.
- Teams should be ready to answer any questions about their design and the reasoning behind it at the Science Games.
- Your team's subsurface cannot weigh more than 5 pounds.

BACKGROUND

Swift Loop is a new alternative to plane travel that uses vibrations to move people and things quickly from place to place. One of the first Swift Loop stations in Canada will be built right here in our town of Settle. The town motto is "We don't settle in Settle. We Thrive."

People in Settle are excited to launch this new technology in their town, but there is a problem with Swift Loop that can only be solved by engineers. When the "Swift Loop" car starts up from the station there is significant shaking that goes as far as 500 metres away from the station! The "Shake" has been shown to be a huge source of kinetic energy that can help shake paint cans, power batteries, and even be part of an amusement park ride.

The downside of the "Shake" is that the station building and the ground beneath it for a 500 m radius need to be rated for a Level 9 earthquake. The Swift Loop Global Corporation has a list of pre-qualified geotechnical engineers and they have hired you to design and demonstrate that your sub-surface design can handle the 'Shake'. The founders of Swift Loop Global Corporation, Steve Stilton and Ariana Kaven, are coming to see what you've come up with. They have a lot riding on this!

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GROUND SHAKES!

MATERIALS LIST

In BC the ground underneath your feet is typically made up of sand, peat, silt, gravel, or clay. There are several everyday household items that have similar properties to these soil types.

Use the list of household items below to build your subsurface.

SOIL TYPE	SIMILAR HOUSEHOLD ITEM
Gravel	• Course ground coffee beans • Rice • Crushed small shell dry pasta
Sand	• Fine ground coffee beans
Silt	• Flour
Clay	• Play-Doh • Corn/Potato Starch
Peat	• Crushed croutons with water • Dry bread crumbs with water

Does your team want to use other materials to represent these soil types? Teams can come up with their own materials for each layer but those materials should have the same characteristics as the soil type they represent.

Teams who come up with their own material types for these soil layers will need to explain to the judges why they picked that material.

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GROUND SHAKES!

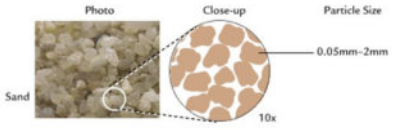
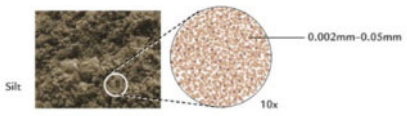
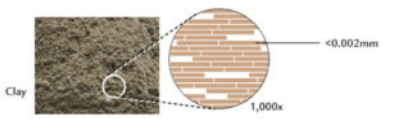
THINGS TO THINK ABOUT:

WHAT IS SOIL?

Soils are formed when rocks get worn down or plants decay. This is called weathering and can take a long time. Weathering happens when rocks and plants are broken down into smaller pieces by things like water, ice, acid, and salt. Even plants and animals can act as agents of weathering. The soils, or products of weathering, could stay in the same place or may be moved to other places by ice, water, wind, and gravity.

TYPES OF SOIL

There are five basic types of soil:

SOIL TYPE	CHARACTERISTICS	SAMPLE
Gravel	• Small, irregular pieces of rocks and stone • Size: 2 mm–64 mm	
Sand	• Small pieces of weathered rock • Coarse and loose • Water drains through it easily • Size: 0.05 mm–2 mm	
Silt	• Smaller pieces than sand (feels like flour) • Holds water better than sand • Size: 0.002 mm–0.05 mm	
Clay	• Smaller pieces than silt • Very small space between the pieces • Difficult for water and air to move through • When wet, can be moulded into shapes • Size: 0.002 mm or smaller	
Peat	• Decay of plant life • Dark brown to black colour • Very spongy and squishy • Unsuitable for building foundation	

Most soils are made up of a combination of these. How soil types are mixed determines how the soil looks and feels.

SOIL PARTICLES AND PORES

The pieces, or particles, that make soil are not strongly bonded together like metal. Soil particles are free to move on and around one another. Think of soil particles kind of like building blocks. They move and shift based on other factors around them.

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GROUND SHAKES!

Unlike building blocks, soil particles are not the exact same size and shape. This means that there is room between soil particles that can be filled by air or by water. The spaces between soil particles are called pores. The pores around soil particles play an important role in how air and water moves through the soil. This can play a key role in how stable the ground is when it rains or during a storm.

The pores in the soil may be filled with air, water, or partly with water and partly with air. If all pores filled with air, then the soil is dry. If all pores filled with water, the soil is saturated. This makes the soil more solid or dense. Dense soil is more stable than loose soil and better for building.

WHAT IS PERMEABILITY?

Water impacts the soil as it travels through it. If too much water is held in the pores space, it will put pressure on the soil around it. Think of it as water holding up the soil.

Permeability describes how much water flows through the soil. For example, if the soil is very permeable it means water can easily travel through the pores, like gravel. If the soil is not permeable, it means water cannot travel through the soil, like clay. The longer it takes for the water to travel through the soil the more time it will need to make the soil denser. It is very important as it will affect the settlement of buildings and the amount of pressure the soil can withstand.

WHAT IS SETTLEMENT?

When you build a structure like a home, the ground will move if no preparation is done on the subsurface. The subsurface shifts with this weight, the building on top will move as well and can become unbalanced. This is called settlement. To prevent unbalanced movement of the building, engineers will think of ways to prepare the subsurface by removing and replacing with good engineering material such as gravel and sand or making the pores smaller.

WHAT IS SOIL COMPACTION?

It is possible to make the pores between soil particles smaller. This can be done through pounding or vibrating the soil using machineries and it is call compaction. In the olden days, animals' feet were actually used to compact the soil. When you compact the soil, it means you are pressing or moving the soil particles closer together. Air and water is pushed out from the pore space. Sometimes, when compacting the soil, you will need to add some water. Water will act as a lubricant and help the particles move. The soil will be easier to work with. Beware, too much water will make the soil weak so it cannot compact.

WHAT DO GEOTECHNICAL ENGINEERS THINK ABOUT?

Anything placed on the ground will impact the way soil moves or shifts. Geotechnical engineers think about what type of soil is in the ground. They look at the soil type, particle size, permeability, and pore space, and determine if the ground is solid. If the ground is not solid, ground improvement such as compaction is needed.

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DIVISION 2 MYSTERY ACTIVITY

TUNNEL AWAY

For this activity Division 2 teams will have to work together in pairs to build a tunnel underneath the Fraser River. You'll need to communicate with your paired team to be successful with this activity.

INSTRUCTIONS

1. **Learn How to Program Your Robot:** Review the instructions for your robot. Test out inputting commands. Make sure your team understands how to program the robot before moving on to the next step.

2. **Pick Your Starting Point:** Roll a dice to select your robot's starting position on the map.

3. **Connect with Your Paired Team:** Send a delegate from your team to talk to a member of your paired team. You need to agree on a meeting point for your tunnels. There will be three meeting points to choose from in the middle of the Fraser River.

4. **Measure Your Route:** Pick a route from your starting point to the meeting point and start measuring. You will need to create a path that your robot can travel and measure it out. Look out for the boundary lines and other obstacles. These cannot be crossed by your robot and must be avoided.

5. **Map Out Your Route:** Record your robot route on a piece of paper. List out the measurements and angles so that you can change them later if you need to.

6. **Program in Your Instructions for the Robot:** Using your planned route, program the instructions for your robot.

7. **Run the Robot Through the Route:** Did your robot make it to the meeting point? If not, adjust your route, update your robot instructions and try again.

8. **Switch it Up:** After 10 minutes you will rotate and repeat steps 2–7 with a new paired group.

RULES

- Each team will measure every distance taking into account all obstacles and then program their robot to hit the target.
- Teams can speak to one another because in real life, the best results are generated with collaboration.
- Robots cannot go over or through a boundary line or obstacle.
- To reach the meeting point, any part of the robot must touch the Meeting Point Sheet.
- Robots must start completely within the chosen Starting Point Sheet.

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DIVISION 2 MYSTERY ACTIVITY

TUNNEL AWAY

BACKGROUNDER

PROGRAMMING YOUR ROBOT

Your robot can be programmed to move with two simple types of instructions.

- **Move Forward/Backward:** You will need to tell the robot how far to move in feet/inches. For example: Move forward 10 inches.
- **Turn Left or Turn Right:** You will need to tell the robot the degree of the turn that it should make. Degrees can be listed in 45º, or 90º. For example: Turn 45º right.

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DIVISION 2 MYSTERY ACTIVITY
ELECTRIC PUZZLES

Engineers are problem solvers. They use their knowledge of science and engineering to make the world better. Electrical engineers are a specific type of engineer. They use their knowledge of electrical circuits to develop components for everything from the circuits in a small toy car to life support systems in hospitals to electrical systems for a rocket.

In this activity teams will work together to create different electrical circuits using the Logic Gate Exploration Board and wires provided. Teams will be awarded points based on teamwork, creativity, and how many circuit puzzles your team is able to solve.

INSTRUCTIONS

1. **Check Out Your Materials:** Each team will be provided with two Logic Gate Exploration Boards, wires, and power supply to create your circuits. Teams should review the available logic types before beginning their build. Teams will also be provided with a Challenge Package that contains circuit problems for your team to solve. Each Logic Problem is listed on a separate sheet of paper. Use these sheets to record your answers and show the judges how you solved the circuit problem.

2. **Review the Logic Problem:** Read the first Logic Problem in your team's Challenge Package. Each Logic Problem needs to be translated from word form into a circuit. Make sure to go through each Logic Problem in order. These challenges will get more difficult as you progress.

3. **Solve the Logic Problem:** Teams will need to translate the word problem on their Logic Problem Sheet into a circuit solution. Complete the Truth Table to help your team find a circuit solution. Then you'll draw out the solution as a diagram. Use the symbols provided on the Logic Problem Sheets to show your answer.

4. **Create your Logic Solution:** Teams will then build the circuit that matches their word problem and diagram.

5. **Show Your Solution:** After their circuit is built and the diagram is completed each team will present it to a judge for review. The judge will record when it has been completed.

6. **Start Your Next Problem:** Teams will repeat Steps 2 through 5 for each of the challenges provided.

RULES

- Teams can only use the Logic Gate Exploration Boards provided and the supplied wires.
- Teams must provide a diagram (schematic) for each solution created on the boards .
    a. Judges will not sign off on the completed Logic Problems unless the team has completed the diagram correctly and demonstrated a functional circuit.
- The circuit solution must be completed on a single Logic Gate Exploration Board.

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In this activity teams will work together to create different electrical circuits using the Logic Gate Exploration Board and wires provided. Teams will be awarded points based on teamwork, creativity, and how many circuit puzzles your team is able to solve.

INSTRUCTIONS

1. **Check Out Your Materials:** Each team will be provided with two Logic Gate Exploration Boards, wires, and power supply to create your circuits. Teams should review the available logic types before beginning their build. Teams will also be provided with a Challenge Package that contains circuit problems for your team to solve. Each Logic Problem is listed on a separate sheet of paper. Use these sheets to record your answers and show the judges how you solved the circuit problem.

2. **Review the Logic Problem:** Read the first Logic Problem in your team's Challenge Package. Each Logic Problem needs to be translated from word form into a circuit. Make sure to go through each Logic Problem in order. These challenges will get more difficult as you progress.

3. **Solve the Logic Problem:** Teams will need to translate the word problem on their Logic Problem Sheet into a circuit solution. Complete the Truth Table to help your team find a circuit solution. Then you'll draw out the solution as a diagram. Use the symbols provided on the Logic Problem Sheets to show your answer.

4. **Create your Logic Solution:** Teams will then build the circuit that matches their word problem and diagram.

5. **Show Your Solution:** After their circuit is built and the diagram is completed each team will present it to a judge for review. The judge will record when it has been completed.

6. **Start Your Next Problem:** Teams will repeat Steps 2 through 5 for each of the challenges provided.

RULES

- Teams can only use the Logic Gate Exploration Boards provided and the supplied wires.
- Teams must provide a diagram (schematic) for each solution created on the boards .
    a. Judges will not sign off on the completed Logic Problems unless the team has completed the diagram correctly and demonstrated a functional circuit.
- The circuit solution must be completed on a single Logic Gate Exploration Board.